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or main switch control signal is, preferably, a differentiation circuit connected between the control of the main switch and the control primary winding. In this flyback converter, the control signal applied to the synchronous rectifier can be supplied by the switching circuit described above. Again, the switching circuit can be a transistor switching circuit and can have a bias potential applied thereto taken from a DC bias circuit connected with a secondary winding and including at least one rectifying diode. The turning ON and OFF of the transistors that make up the transistor switching circuit is, of course, taken from the control secondary winding.

In the preferred exemplary embodiments described herein, power losses due to cross conduction between the main switch and the synchronous rectifier can be eliminated or nearly entirely eliminated and reverse recovery losses can likewise be eliminated or nearly entirely eliminated.

Both of the above-described embodiments of the present can be implemented by using either a separate transformer or one integrated with the main transformer. The transformer can be discrete component of its own or can be imbedded in a PCB carrying the converter circuitry. The driving transformer in both embodiments can be embedded into the main transformer of the converter.

The foregoing and other objects, features and advantages of the present invention will be more readily understood upon consideration of the following detailed description of the invention together with the following drawings.

Brief Description of the Drawings

Fig. 1A is a schematic of a prior art flyback converter with a synchronous rectifier in the output section;

Fig. 1B is a series of plots of the main voltage and current waveforms, versus time, for the continuous-conduction mode of operation or CCM of the prior art converter of Fig. 1A;

Fig. 1C is a series of plots of the main voltage and current waveforms, versus time, for the discontinuous-conduction mode of operation or DCM of the prior art converter of Fig. 1;

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Fig. 1D is a series of plots of the main voltage and current waveforms, versus time, for the critical-conduction mode of operation, the limit case between CCM and DCM, of the prior art converter of Fig. 1;

Fig. 2 illustrates the basic schematic of the flyback converter with synchronous rectifier in the output section according to this invention;

Fig. 3 is a schematic of a synchronous rectifier like that of the converter of Fig. 2 including the control according to this invention;

Fig. 4A is a series of plots of the main voltage and current waveforms, versus time, for the continuous-conduction mode of operation or CCM of the converter of Fig. 2 according to this invention;

Fig. 4B is a series of plots of the main voltage and current waveforms, versus time, for the discontinuous-conduction mode of operation or DCM of the converter of Fig. 2 according to this invention; and

Fig. 5 is a series of plots of the driving technique of the synchronous rectifier of the converter of Fig. 2 according to this invention.

Detailed Description

The approach used to control the synchronous rectifier of a DC-DC flyback converter according to this invention is first described in relation to the improved basic schematic of the flyback converter shown in Fig. 2. In the flyback converters of Figs. 1 and 2, like elements bear like reference numerals. The voltage source 2 supplies the input circuit formed by the primary winding 6 of the power transformer 4 connected in series with the switching MOSFET S1. The switching transistor S1 is controlled by a signal $V_c(S1)$. The output circuit of the flyback converter contains the secondary winding 8 of the power transformer 4 connected in series with the synchronous rectifier S2 and the output load 24. The output voltage obtained on the load is filtered by the capacitor 22. The body diode 18 of the synchronous rectifier is also represented as it plays a role in the operation of the circuit. According to one preferred embodiment of this invention, besides the main switch control signal $V_c(S1)$, which controls the main input switching transistor S2 in Fig. 1, two supplementary signals are used to process the final controlling signal $V_c(S2)$ for the output synchronous rectifier S2. These are